Standard for Wet Ponds

Definition

A stormwater retention impoundment created by either constructing an embankment or excavating a pit which retains a permanent pool of water used for water quality improvement.

Purpose

Long-term storage of stormwater runoff provides for mechanical settling of fine suspended sediments as well as biological processing and removal of nutrients from the stormwater before being discharged by displacement of a subsequent storm event. Permanent pools also protect deposited sediments from resuspension. Wet ponds provide aesthetic and recreation benefits as well as fire protection and (irrigation) water supply. Wet ponds may also be used for flood and downstream erosion control through the use of multi-stage outlets.

Conditions Where Practice Applies

A reliable source of runoff or ground water must be available to maintain the volume of the permanent pool. Wet pond basins are restricted to moderate to large drainage areas, often greater than 20 acres. A wet pond basin is an appropriate water quality practice in residential and commercial areas where nutrient loadings are expected to be high.

Wet ponds may be limited by the potential for discharge water to be heated in the permanent pool during summer months and should not be used if the receiving waters are ecologically sensitive to temperature change.

Design Criteria

Design Approach:

Two alternative approaches can be used to establish design criteria for water quality purposes in wet detention ponds. The first approach is based on solids settling and assumes that all pollutant removal within the pond occurs due to sedimentation. The second approach treats the wet pond as a lake with controlled levels of eutrophication to account for the biological and physical/chemical processes that are principal mechanisms for pollutant removal. Both approaches relate the pollutant removal efficiencies to hydraulic residence time.

Design approach should be selected based upon the target of the control efforts as well as site and economic constraints. The controlled eutrophication approach requires longer residence times and larger storage volumes comparable to those of the solids settling approach. However, where the chief concern is to control nutrient levels in waters such as lakes and reservoirs, it is then advantageous to use the controlled eutrophication. If the major goal is the removal of a broad spectrum of pollutants, especially those adsorbed onto suspended matter, it may be preferable to base the design criteria on the sedimentation models. Presently, most pond water quality practice designs for runoff pollution control rely heavily on the sedimentation process.

1. Design Variations

Two basic design variations are available to satisfy particular site-specific conditions or requirements. These are:

A. A wet pond with a permanent pool of water with a volume equal to or greater than four times the runoff volume. The runoff displaces a portion of the pool volume and is treated during the dry period and in turn is displaced by the next storm. A schematic of this wet pond design is illustrated in Figure 1.

B. A multipurpose multistage wet pond designed to provide stormwater management (peak attenuation etc.) in addition to water quality enhancement.

2. Design

General hydrologic and hydraulic criteria for on-site (drainage area 20-100 acres) and regional (drainage area 100-300 acres) wet pond water quality practices are summed up in Tables 1a & b. Some important design parameters are discussed below.

A. Pool Volume

The volume of the permanent pool, in relation to the drainage area or runoff volume, is the most critical parameter in the sizing of the wet pond and its ability to remove pollutants.

For a useful reduction in pollutant loading, the VB/VR ratio must be greater than three, and preferably four. (VB = Volume of the basin; VR = Volume of runoff generated by the design storm)

TABLE 1a - Permanent Pool

Design Parameter	Recommended Criteria On-Site Wet Pond
1. Storage Volume	a. At the minimum VB/VR > 4 b. Nutrient removal (P=65%, Solids 85-90%) c. VB/VR >4
2. Depth	3 to 6 feet
3. Pool Surface Area	>0.25 acres
4. Drainage Area	Minimum of 20 acres
5. Side slopes	5:1 to 10:1 (H:V)
6. Length : Width Ratio	3:1 or greater (goal)
7. Soils at site	Hydrologic Soil Groups B, C and D (Compaction may be required on A or B soils)

TABLE 1b - Peak Discharge Control

Hydrologic Criteria	Two Year Storm Event	10 or 100 Year Storm Event
1. Design criteria	Reduce peak discharge to 50% of pre-development	Reduce peak discharges to 75% and 80% of pre-development. May require matching pre- and post- Q to the point.
2. Storage Volume	Obtained from TR-55, TR-20, HEC-1 or other methods which produce similar results.	
3. Water Surface Elevation	Upper limit at bottom of 10 or 100-year storage. Lower limit at top of extended detention storage.	According to flood routing techniques; must not exceed Emergency Spillway

Source: After Hartigan and Schueler, 1989

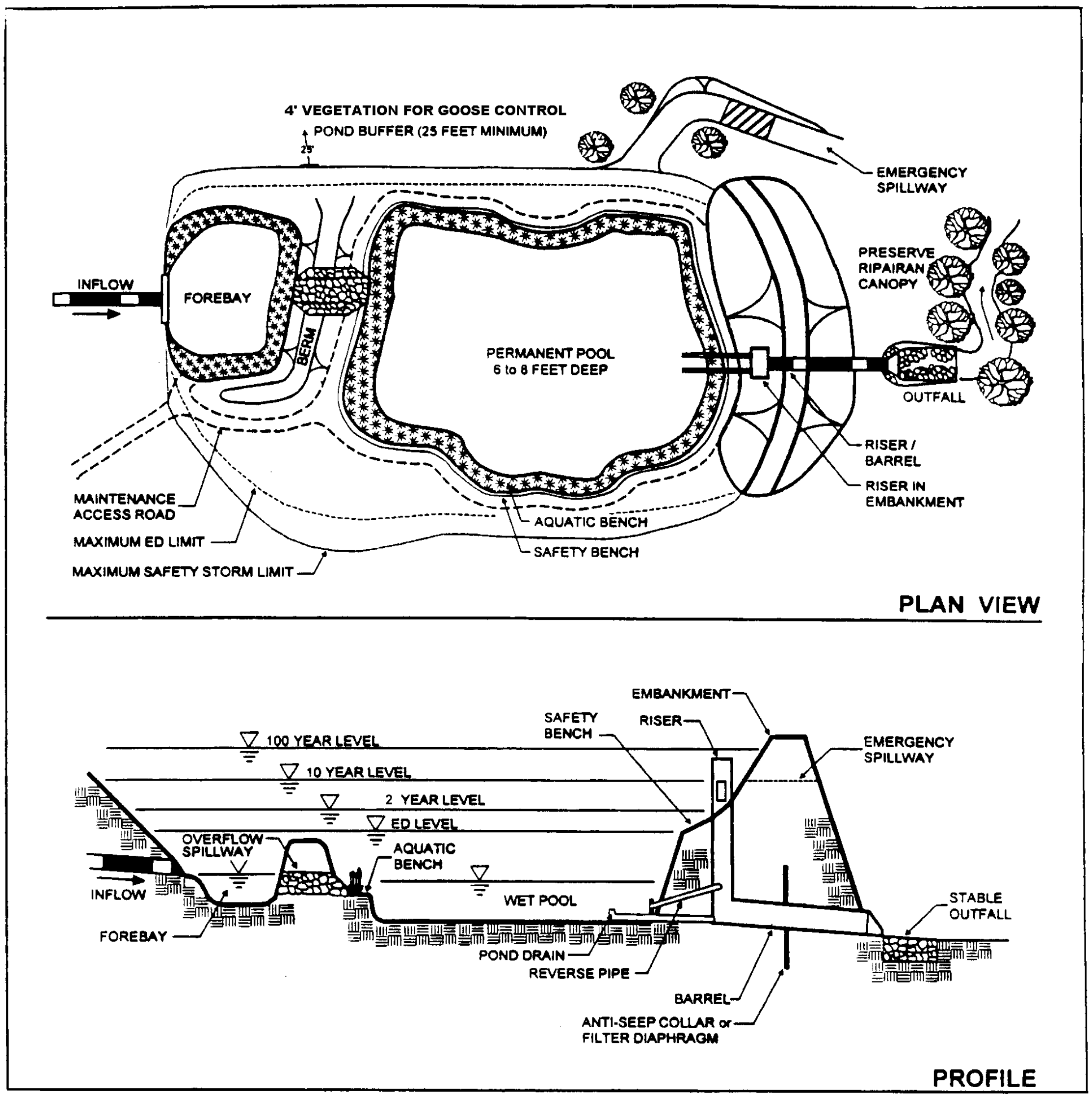

Figure 1. Typical Wet Pond Source: Maryland Dept. of Environment

B. Pool Depth

The depth of the permanent pool is an important design parameter since it affects solids settling. Mean depth of the pool is obtained by dividing the storage volume by the pool surface area. The pool should be shallow enough to avoid thermal stratification and deep enough to minimize algal blooms and resuspension of previously deposited materials by major storms and wind generated disturbances. Prevention of thermal stratification will minimize short-circuiting and maintain aerobic bottom waters, thus maximizing pollutant uptake and minimizing the potential release of nutrients to the overlying waters. An average depth of 3 to 6 feet is sufficient to maintain the environment within the pool. A ten-foot wide and one-foot deep bench is needed around the perimeter of the pool to promote aquatic vegetation and to reduce a potential safety hazard to the public. Shallow depth near the inlet structure is desirable to concentrate sediment deposition in a smaller and easily accessible area. The riser should be located in a deeper area to facilitate withdrawal of cold bottom water for the mitigation of downstream thermal impacts, if any.

C. Minimum Surface Area of Permanent Pool

Minimum surface area will be contingent upon local topography, minimum depth and solids settling guidelines. For on-site wet pond water quality basins, **minimum pool surface area is 0.25 acres.**

D. Minimum Drainage Area and Pond Volume

The minimum drainage area for an on-site wet pond water quality structure should be large enough to sustain the wet pond during the summer periods. **A minimum drainage area of 20 acres** is required to sustain the desired dry weather inflow. In general, **4 acres of contributing drainage area are needed for each acre-foot of storage**.

E. Side-Slopes

Refer to Appendix of the Standards for Soil Erosion and Sediment Control in New Jersey for structural guidelines for stormwater management basins.

F. Pond Configuration

Length to width ratio of the pond should be as large as possible to simulate conditions found in plug flow reaction kinetics. Under the ideal plug flow conditions, a “plug or “pulse” of runoff enters the basin and is treated by chemical reactions taking place as well as by physical processes of dispersion and settlement as the pulse travels the length of the pond. The length to width ratio should be at least 3:1 to maximize the treatment. In cases where it is impractical to construct long wet ponds, the hydraulic residence time may be lengthened by means of baffles.

G. Outlets

The riser structure should be equipped with a bottom drain pipe, sized to drain the permanent pool within 40 hours so that sediments may be removed mechanically when necessary. The drain pipe should be controlled by a lockable gate valve at the outlet. Refer to Appendix of the Standards for Soil Erosion and Sediment Control in New Jersey for additional structural guidelines for stormwater management basins.

Considerations

A wet pond basin contains a permanent pool in addition to the flood control storage. To maintain water quality (oxygen levels), control mosquito breeding and prevent stagnation, a sufficient inflow of water (either surface or ground water) is necessary on a regular basis. A fountain or solar powered aerator may be used for oxygenation of water. The potential effects of sediment loading on the permanent pool should be considered when determining if a site is suitable for a wet pond basin. The use of existing lakes and ponds as wet ponds for treatment of stormwateris prohibited.

A well designed pond will accumulate considerable quantities of sediment. The cleanout cycle for a wet pond in a stabilized watershed is approximately 10 years, with sediment removal at each cycle costing as much as 20 - 40% of the initial construction cost.

Thermal Effects of Stored Runoff:

Thermal effects of the wet pond must be considered since the pool acts as a heat sink during the summer period, between the storm events. When the water is displaced from the pool, it may be as much as 10 degrees Fahrenheit warmer than naturally occurring baseflow. Large impervious surfaces can also significantly raise the temperature of runoff in the summer months. The net result of elevated pool temperatures may have an adverse impact on downstream coldwater uses such as trout production. Most streams in mature urban areas do not fall into this category. However, in newly urbanizing areas, the pond designer should pay special attention to the potential of thermal effects on downstream water bodies supporting cold water fisheries. Thermal impacts in such areas may be eliminated or mitigated by: (a) prohibiting wet ponds altogether, (b) diverting most of the baseflow and bypassing the wet pond entirely, (c) utilizing a design with a drastically undersized permanent pool, (d) using a design with a deep pool and positioning the inlet of the outlet pipe to withdraw cooler water from near the bottom, (e) planting shade trees on the periphery of the pool to reduce warming in the summer, (f) directing baseflow through the wetland while channeling stormflow to a fringe pool area and (g) employing a series of pools in sequence rather than a single one.

Vegetation:

Aquatic vegetation plays an important role in the pollutant removal dynamics of the wet pond. Soluble pollutants, especially nutrients, are removed through biological assimilation by both phytoplankton and macrophytes. Wetland plants can help to keep algal proliferation in check by limiting the amount of nutrients available to the phytoplankton. In addition, an organically enriched wetland substrate will provide an ideal environment for bacterial populations to metabolize organic matter and nutrients. Aquatic vegetation may also aid in the regulation of pond water temperature.

Marsh vegetation can also enhance the appearance of the wet pond, stabilize the side-slopes, serve as wildlife habitat and can temporarily conceal unsightly trash and debris. Water tolerant species of vegetative cover for wet pond surfaces should be used. To promote lasting growth, grasses and other vegetative covers should be compatible with prevailing weather and soil conditions and tolerant of periodic inundation and runoff pollutants. An adequate depth of topsoil should be provided below all vegetative covers in uplands. A minimum thickness of six inches is recommended.

The wet pond should, therefore, be designed to promote dense growth of appropriate wetland plant species along the banks from two feet below to approximately one foot above the surface of the permanent pool. A 10-15 foot wide wetland vegetation bench, one foot below the pool surface should be established along the perimeter of the pond.

In cases where relatively permeable soils (hydrologic groups A and B) are encountered, the risk of drawdown may be minimized by installing a six inch clay liner at the bottom of the pond or simply by compacting the pond soils.

Readily visible stormwater management facilities receive more and better maintenance than those in less visible, more remote locations. Readily visible facilities can also be inspected faster and more easily by maintenance and mosquito control personnel.
If maintained at the recommended three to six foot depth, the permanent pool can serve as aquatic habitat.

Operations and Maintenance

The facility must be readily accessible from a street or other public right-of-way. Inspection and maintenance easements, connected to the street or right-of-way, should be provided around the entire facility. The exact limits of the easements and right-of-ways should be specified on the project plans and other appropriate documents. Access roads and gates should be wide enough to allow passage of necessary maintenance vehicles and equipment, including trucks, backhoes, grass mowers and mosquito control equipment. In general, the minimum right-of-way width of 15 feet and a minimum roadway width of 12 feet is recommended. To facilitate entry, a curb cut should be provided where an access road meets a curbed roadway. To allow for safe movement of maintenance vehicles, access ramps should be provided to the shoreline of all facilities with side slopes greater than 5 feet in height. Access ramps should not exceed 10% in grade and should be suitably stabilized to prevent damage by vehicles and equipment. Turnarounds should be provided where backing-up is difficult or dangerous. To expedite overall maintenance, vehicle and equipment staging areas should be provided at or near each facility site.

A program of monitoring the aquatic environment of a permanent pond should be established. Water quality, aeration, vegetative growth and animal populations should be monitored on a regular basis. The timely correction of an imbalance in the ecosystem can prevent more serious problems from occurring. Problems such as algae growth, excessive siltation and mosquito breeding should be addressed and corrected immediately.

To minimize maintenance efforts, the use of existing, undisturbed site vegetation is encouraged as long as the existing site topography provides adequate storage volume. Where disturbance of existing vegetation cannot be avoided, replacement with low maintenance vegetation with strong disease resistant and allelopathic (self-weeding) characteristics is encouraged. In general, grass will be easier to establish and will provide better erosion control than other types of ground cover vegetation. The use of grass varieties that are relatively slow growing and tolerant of poor soil conditions will minimize routine maintenance such as mowing and fertilizing. The need for supplemental fertilizing can be substantially reduced when vegetative cover includes a percentage of nitrogen fixing species such as legumes. In addition to minimizing maintenance costs, a reduction in applied fertilizer will also minimize the potential detrimental effects of nitrogen and nitrate runoff.

To control weeds, disease and pests, a regularly scheduled program of mowing and trimming of side-slopes and embankments should be tailored to each stormwater management facility based on site conditions, grass type and seasonal variations. Grassed areas also require periodic fertilizing, dethatching and soil conditioning to maintain healthy growth. Trees, shrubs and other vegetative cover also require periodic maintenance such as fertilizing, pruning and pest control to maintain healthy growth.

A regularly scheduled program of debris and trash removal will reduce the chance of outlet structures, trash racks and other components becoming clogged and inoperable during storm events. In addition, removal of these items eliminates potential mosquito breeding habitats and damage to the vegetated areas of the basin. Disposal of debris and trash must comply with local, state and federal waste regulations. Only suitable disposal/recycling sites should be used.

Inspections by qualified personnel should be conducted at least once a year. Inspections should occur during wet weather to verify that the basin is meeting targeted detention times. Evidence of clogging or rapid release should be investigated. In addition, subsidence, erosion, cracking, unwanted tree growth, condition of the emergency spillway, accumulation of sediment around outlets etc. shall be cause for corrective maintenance measures to be undertaken . These inspections should be used to determine the effectiveness of the regular maintenance schedule as well as determine the timing of corrective maintenance procedures.